10.   Body Weight

10.1   Introduction

        Body weight is an important variate in risk assessment that is used in calculating dose (mg/kg*body wt). Many of the studies that OEHHA used to generate the distributions and point estimates collected body weight data on the subjects in the study. The consumption rate for each subject was divided by the body weight of that subject, and distributions of consumption per unit body weight per day were generated. However a few of the studies, such as the one used to determine fish consumption rate, did not collect body weight information on the subjects. Therefore a review of the body weight literature was conducted and appropriate body weight defaults were selected for our purposes. The published literature on body weight is mainly based on data gathered in the first National Health and Nutrition Examination Survey conducted between 1970 and 1974, and more recently in the second National Health and Nutrition Examination Survey (NHANES II).

10.2   Empirical Distributions

10.2.1   NHANES II (U.S.EPA, 1997)

        NHANES II was conducted on a nationwide sample of about 28,000 persons, aged 6 months to 74 years, from the civilian, non-institutionalized population of the United States. The sample was selected so that certain 'at risk' subgroups (low income, preschool children, elderly) were over sampled. Since the survey was meant to be representative of the U.S. population, the raw data were weighted to reflect the age structure, sex and race of the population at the time of the survey. The survey began in 1976 and was completed in 1980. The mean body weights of adults and children and their standard errors are given in Table 10.1. The average value of 71.8 kg for adults is the basis for the human default value of 70 kg.

10.2.2   Report of the Task Group on Reference Man (ICRP, 1975)

        This task group of the International Commission on Radiological Protection (ICRP) reviewed and compiled extensive data on anatomical measurements, elemental composition, and physiological values for the human body. Weight (W), length (L), and surface area (SA) during prenatal life are presented as means +/- standard deviation (SD) as a function of gestational age. The data are based on 13,327 cases. From the data, a number of allometric relations were derived which relate gestational age to average length, and length to surface area and weight. Postnatal life data from a number of sources were reviewed. In addition to charts showing mean body weight ± one SD from 0 to 12 years and from 0 to 56 years by sex, the following defaults were recommended:

> Newborn male: mean = 3.5 kg; SD = ± 0.59 kg;
> Newborn female: mean = 3.4 kg; SD = ± 0.59 kg;
> Adult male: mean = 71.7 kg; SD = ± 10 kg;
> Adult female: mean = 56.7 kg; SD = ± 8.6 kg.

Tabular data relating height in cm to body weight in kg for 8 age groups 18-79 years are given for the 25th, 50th and 75th percentiles. These data are summarized in Table 10.2 for the reference total body heights of 170 cm for males and 160 cm for females.

10.2.3   NCHS (Hamill et al. 1979)

The National Center for Health Statistics (NCHS) prepared percentile curves for assessing the physical growth of children ages 0 to 36 months. Smoothed percentile curves were derived for body weight, length, and head circumference. Separate sets were produced for male and female children. The data used were from the Fels Research Institute, Yellow Springs, Ohio. Body weight percentiles of 5th, 10th, 25th, 50th, 75th, 90th, and 95th are given for ages of 0 (birth), 1, 3, 6, 9, 12, 18, 24, 30, and 36 months for each sex. The data were smoothed by cubic spline approximation.

10.3   Modeled Distributions

10.3.1   Brainard and Burmaster, 1992

These authors examined data on height and weight of adults from NHANES II and fit bivariate distributions to the tabulated values for men and women separately. The survey tabulated the height and weight of 5916 men and 6588 women aged 18-74. After statistically adjusting the raw data to reflect the whole U.S. population aged 18-74 for age structure, sex, and race the U.S. Public Health Service published results for an estimated 67,552 men and 74,167 women. Defining the variables height (Ht) in inches and weight (Wt) in pounds the authors observed that the marginal histograms for Ht were symmetrical and for Wt were positively skewed. Consequently they defined and analyzed the additional variable lnWt for each sex. For men straight lines were fit to cumulative values and z-scores for lnWt and Ht with R^2 values of 0.999. For weight (lb), the estimated values of $\mu \pm \sigma$ for men are exp (5.13 ± 0.17). For women the visual fit of the line to lnWt was not as good, but adequate. The estimated values (lb) of $\mu \pm \sigma$ are exp(4.96 ± 0.20). The body weight arithmetic mean (lb) and standard deviation for men and women are 171 ± 29.4 and 145 ± 29.4. The body weight mean and standard deviation in kg for men and women are 77.9 ± 13.3 and 66.1 ± 13.6, respectively. The conversion from $\mu \pm \sigma$ to arithmetic mean and standard deviation is done using the following formulas (Burmaster and Hull, 1997).

$$Amean = \exp(\mu + 0.5 * \sigma^2)$$

$$AStdDev = \exp(\mu) * \sqrt{\exp(\sigma^2) * [\exp(\sigma^2) - 1]}$$

10.3.2   Finley et al., 1994

These authors summarize body weight distributions analyzed by Brainard and Burmaster and present a combined standard distribution for equal numbers of adult men and women of 71.0 ± 15.9 kg. The 50th and 95th percentiles of the combined distribution are 70 and 101 kg,

respectively. The distributions for adult males and females are given as 78.7 ± 13.5 kg and
65.4 ± 15.3 kg, respectively. Finley et al. also present annual age group weight distributions for
children 18 years of age and under (Table 10.3). These distributions are considered by the
authors to reflect almost entirely interpersonal variation due to the large sample sizes and
consistent methodology used in the NHANES II survey.

10.3.3 Burmaster et al. 1977

In this paper, Burmaster et al. 1997 fit normal and lognormal distributions to the male and
female child data sets from the NHANES II Survey. The authors concluded that the lognormal
distributions consistently fit the points better than did normal distributions.

Table 10.1   Body Weight of Adults and Children from NHANES II (kg)[a]

Age Group, yr	Male		Female		Male & Female
	Mean	Std Dev	Mean	Std Dev	Mean
Adults (Years)					
18<25	73.8	12.7	60.6	11.9	67.2
25<35	78.7	13.7	64.2	15.0	71.5
35<45	80.9	13.4	67.1	15.2	74.0
45<55	80.9	13.6	68.0	15.3	74.5
55<65	78.8	12.8	67.9	14.7	73.4
65<75	74.8	12.8	66.6	13.8	70.7
18<75	78.1	13.5	65.4	14.6	71.8
Children					
6-11 months	9.4	1.3	8.8	1.2	9.1
1 year	11.8	1.9	10.8	1.4	11.3
2 year	13.6	1.7	13.0	1.5	13.3
3 year	15.7	2.0	14.9	2.1	15.3
4 year	17.8	2.5	17.0	2.4	17.4
5 year	19.8	3.0	19.6	3.3	19.7
6 year	23.0	4.0	22.1	4.0	22.6
7 year	25.1	3.9	24.7	5.0	24.9
8 year	28.2	6.2	27.9	5.7	28.1
9 year	31.1	6.3	31.9	8.4	31.5
10 year	36.4	7.7	36.1	8.0	36.3
11 year	40.3	10.1	41.8	10.9	41.1
12 year	44.2	10.1	46.4	10.1	45.3
13 year	49.9	12.3	50.9	11.8	50.4
14 year	57.1	11.0	54.8	11.1	56.0
15 year	61.0	11.0	55.1	9.8	58.1
16 year	67.1	12.4	58.1	10.1	62.6
17 year	66.7	11.5	59.6	11.4	63.2
18 year	71.1	12.7	59.0	11.1	65.1
19 year	71.7	11.6	60.2	11.0	66.0

[a] From U.S. EPA, 1997

Table 10.2   Median and Quartile Human Body Weights by Age; United States, 1960-2[a]

Age Group, yr	25%	50%	75%
Males			
18-24	63	68	76
25-34	67	74	85
35-44	68	74	81
45-54	68	75	85
55-64	67	76	85
65-74	64	72	78
75-79	66	83	88
18-79	66	73	82
Females			
18-24	51	55	60
25-34	52	58	66
35-44	57	63	73
45-54	57	64	73
55-64	61	68	82
65-74	60	65	74
75-79	55	66	71
18-79	56	62	72

[a] Weights in kg for reference heights of 170 cm male, 160 cm female
(Adapted from ICRP, 1975)

Table 10.3   *Summary of Distribution Factors for Body Weight by Age*[a]

Age, yr	Arithmetic Mean, kg	SD, kg
0.5-1	9.4	1.2
1-2	11.8	1.4
2-3	13.6	1.6
3-4	15.7	1.7
4-5	17.8	2.3
5-6	20.1	2.8
6-7	23.1	3.5
7-8	25.1	3.8
8-9	28.4	5.2
9-10	31.3	5.0
10-11	37.0	7.5
11-12	41.3	10.5
12-13	44.9	10.0
13-14	49.5	10.5
14-15	56.6	10.3
15-16	60.5	9.7
16-17	67.7	11.6
17-18	67.0	11.5

[a] Adapted from Finley et al. (1994).

10.4 Recommendations

10.4.1 Point Estimate Approach

The point estimates for body weight in kg for 9, 30 and 70 years are calculated by taking the time weighted average of the mean body weights for ages 0.5 through 9, and ages 0.5 through 70 as presented in Table 10.1. In the interest of simplicity males and females are averaged. If a toxicant affects only one or predominantly one gender, the assessor may want to adjust point estimates and distributions of intake parameters to reflect body weight of the gender in question; however, such an adjustment will not result in a significant change in the results of the risk assessment. For the 30-year exposure scenario, the body weight for the 70-year scenario can be used in the interest of simplicity. The use of the time-weighted average approach allows for a more accurate calculation of dose from ages 0-9 and ages 0-70 because an estimate of the change in body weight as an individual grows is factored in.

Table 10.4   *Point Estimates for Body Weight (kg)*

	Ages 0-9	Age 0-70
Body weight	18	63

10.4.2 Distributions for Stochastic Approach

OEHHA is not recommending distributions for a stochastic approach because most of the consumption rate distributions that we derive from raw data, or recommend from the literature already incorporate subject body weight. It may be appropriate to use body weight distributions when the correlation between body weight and the consumption rate of interest is known. For the fish consumption distribution we have chosen to divide the consumption distribution by a point estimate of body weight because the correlation is not known. If body weight distributions are used without the appropriate correlation broad distributions are generated that may overestimate the variability in the parameter of interest. The available data in the literature may be adequate to generate approximate ages 0-9 and ages 0-70 body weight distributions if such distributions are needed.

10.5   References

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